CRITERION OF CLOSURE AND ORIGIN (CCO)

A Universal Structural Theory of Scientificity, Parametric Incompleteness, and Internal Generation of Parameters

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Work

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This Work is dedicated to
Stellina – Caterina Giordano

as an act of human, intellectual, and moral recognition,
for the presence, strength, and truth that accompanied
the construction of a work requiring absolute rigor
and total honesty.

Historical positioning

This Treatise is conceived as a foundational work.
It does not introduce a specific model, but a **universal criterion**.

The **Criterion of Closure and Origin (CCO)** provides a necessary and sufficient structural condition of scientific validity for any theory claiming to describe, explain, or model a real phenomenon.

Reader's notice

This text is:

- intentionally non-rhetorical,
- intentionally non-narrative,
- intentionally formal.

The reader is invited to approach it as a **logical–mathematical object**, not as a popular exposition.

PREFACE

This Treatise originates from a simple yet structurally neglected observation in contemporary science:
there exists no universal, formal, and verifiable criterion distinguishing a scientifically closable theory from one that is not.

Modern sciences have produced extremely effective models, while progressively accepting as inevitable the existence of:

- external parameters not generated by the theory,
- constants fixed empirically but not explained,
- "free" degrees of freedom not internally reconstructible,
- estimation procedures replacing causal generation.

This acceptance has never been formalized as a principle.
It has occurred by convention.

The Criterion of Closure and Origin (CCO) is introduced to address this gap, not by proposing a new model, but by introducing a structural criterion.

1.1 Purpose of the Work

The purpose of this Treatise is to define a necessary and sufficient criterion establishing when a theory:

- is structurally closed,

- is scientifically complete,
- is internally reconstructible,
- contains no irreducible informational debt.

The CCO does not assess the empirical truth of a theory.
It assesses its structure.

In particular, the CCO addresses the question:

Can a theory depending on externally fixed parameters, not internally generated, be considered scientifically complete?

1.2 Scope and method

This Treatise adopts a formal, abstract, non-interpretative method.

The introduced notions are:

- independent of the application domain,
- independent of physical semantics,
- independent of historical context,
- verifiable by construction.

The language is intentionally minimal.
Each concept is:

- defined prior to use,

- used consistently,
- referenced without ambiguity.

No narrative examples are introduced.
No metaphors are employed.
No rhetorical justifications are provided.

1.3 Positioning with respect to the literature

This work does not present itself as:

- an alternative physical theory,
- a new particle model,
- a novel learning architecture,
- a philosophical epistemological proposal.

It is positioned as a universal structural criterion, applicable to:

- fundamental physics,
- parametric statistics,
- machine learning,
- systems biology,
- any theory based on dynamics and parameters.

The CCO is both an exclusion criterion and a constructive criterion.

1.4 Structure of the Treatise

The Work is organized as follows:

- Part I: formal foundation of informational systems, dynamics, factors, and reconstructibility;
- Part II: introduction of meta-systems, parameters as external dynamic choices, and structural failure;
- Part III: application of the CCO to real domains (physics, statistics, machine learning, biology);
- Part IV: canonical synthesis of the universal criterion of structural scientificity;
- Appendices: logical schema, falsifiability, replicability, and refutation conditions.

Each part is self-contained with respect to prior definitions and introduces no undefined concepts.

1.5 Methodological notice

The reader will not find in this Treatise:

- epistemic reassurance,
- historical justification,
- pragmatic accommodation.

The CCO yields sharp outcomes.
A theory either is closable or it is not.

This rigidity is not a limitation:
it is a necessary condition for scientific verifiability.

PART I: INFORMATIONAL SYSTEMS AND INTERNAL DYNAMICS

2.1 Informational system

Definition 2.1 (Informational system).
An informational system is an ordered pair

$\Sigma = (S, T)$

where:

- S is a non-empty set (state space),
- T is a subset of S^S (set of internal transformations).

Elements of T represent admissible system dynamics.

2.2 Monoid of transformations

Definition 2.2 (Generated monoid).
Given $T \subseteq S^S$, define M(T) as the smallest subset of S^S such that:

- $id_S \in M(T)$,
- if $f, g \in M(T)$, then $g \circ f \in M(T)$,

- $T \subseteq M(T)$.

$M(T)$ is a monoid under composition.

2.3 Dynamic indistinguishability

Definition 2.3 (Indistinguishability relation).
Given $\Sigma = (S, T)$, define the relation $\sim_\Sigma$ on S as:

$s \sim_\Sigma s' \Leftrightarrow \exists\ f \in M(T)$ such that $f(s) = f(s')$.

Lemma 2.4 (Equivalence).

The relation $\sim_\Sigma$ is an equivalence relation on S.

Proof.

- Reflexive: $id_S(s) = s$.
- Symmetric: identity preserves equality.
- Transitive: composition preserves equality.
  QED.

2.4 Informational factors

Definition 2.5 (Factor).
An informational factor is a function

$$F : S \to W$$

where W is an arbitrary set.

2.5 Internal reconstructibility

Definition 2.6 (Reconstructibility).
Given $\Sigma = (S, T)$ and a factor $F : S \to W$, F is internally reconstructible if:

$$\mathrm{RecFactor}_{\Sigma}(F)$$
$$\Leftrightarrow$$
$$\forall\, s, s' \in S,\ (\, s \sim_{\Sigma} s' \Rightarrow F(s) = F(s')\,).$$

2.6 Informational debt

Definition 2.7 (Informational debt).
A factor F carries informational debt if it is not internally reconstructible:

$$\neg \mathrm{RecFactor}_{\Sigma}(F).$$

2.7 Admissible extensions

Definition 2.8 (Admissible extension).
A system $\Sigma' = (S', T')$ is an admissible extension of $\Sigma = (S, T)$, written $\Sigma \preccurlyeq \Sigma'$, if:

- $S \subseteq S'$,
- $T \subseteq T'$,
- for all $s, s' \in S$:
  $s \sim_{\Sigma} s' \Leftrightarrow s \sim_{\{\Sigma'\}} s'$.

An admissible extension introduces no new distinguishing dynamics on original states.

2.8 Structural failure

Definition 2.9 (Structurally indistinguishable factor).
A factor $F : S \to W$ is structurally indistinguishable if:

- $\neg \mathrm{RecFactor}_{\Sigma}(F)$,
- for every admissible extension $\Sigma \preccurlyeq \Sigma'$, $\neg \mathrm{RecFactor}_{\{\Sigma'\}}(F|_S)$.

Definition 2.10 (FAIL).
A system Σ is in structural failure if there exists a structurally indistinguishable factor:

FAIL(Σ)
⇔
∃ F : F is structurally indistinguishable in Σ.

2.9 Closure of Part I

Part I establishes the formal criterion for determining whether information is internally generated or structurally indebted.
Part II extends these notions to **meta-systems** and **parameters as external dynamic choices**.

PART II — META-SYSTEMS, PARAMETERS, AND PHENOMENAL RECONSTRUCTIBILITY

3.1 Parametric families of systems

Definition 3.1 (Parametric family).
Let Θ be a non-empty parameter set.
A parametric family of informational systems is a collection:

$$\{ \Sigma_\theta : \theta \in \Theta \}$$

where, for each θ,

$$\Sigma_\theta = (S, T_\theta)$$

with fixed state space S and parameter-dependent internal dynamics $T_\theta \subseteq S^S$.

3.2 Parameters as external dynamic choices

Assumption 3.2 (External parameter).
The parameter θ does not belong to the state space S and is not generated by any internal dynamics in T_θ.

The parameter represents an external choice of system dynamics.

3.3 Meta-system of dynamic choices

Definition 3.3 (Choice space).
Define the space of dynamic choices:

$D := \{ \Sigma_\theta : \theta \in \Theta \}$.

Definition 3.4 (Meta-system).

The meta-system associated with the parametric family is:

$\Sigma_D = (D, T_D)$

where $T_D \subseteq D^D$ is the set of admissible transformations between instantiated systems.

Assumption 3.5 (No parameter-generating dynamics).

The meta-system contains no dynamics that generate or modify the parameter:

$T_D = \{ id_D \}$.

Hence:

$M(T_D) = \{ id_D \}$.

3.4 Parameter factor

Definition 3.6 (Parameter factor).
Define the parameter factor:

$P : D \to \Theta$
$P(\Sigma_\theta) := \theta.$

The factor P is surjective by construction.

3.5 Dynamic indistinguishability in the meta-system

Since:

$M(T_D) = \{ id_D \},$

for all $d, d' \in D$:

$d \sim_{\Sigma_D} d' \Leftrightarrow d = d'.$

Dynamic indistinguishability coincides with equality.

3.6 Observable phenomenon

Definition 3.7 (Phenomenon).
An observable phenomenon is a function:

$F : D \to W$

where W is the space of observable outcomes.

Definition 3.8 (Phenomenal equivalence).

Two elements d, d' ∈ D are phenomenally equivalent if:

d ≈_F d' ⇔ F(d) = F(d').

3.7 Phenomenal reconstructibility

Definition 3.9 (Phenomenal reconstructibility).

A factor P : D → Θ is phenomenally reconstructible with respect to F if:

RecFactor^{phen}_{Σ_D}(P;F)
⇔
∀ d, d' ∈ D, (d ≈_F d' ⇒ P(d) = P(d')).

3.8 Relation to dynamic reconstructibility

Lemma 3.10.

In the meta-system Σ_D:

RecFactor_{Σ_D}(P) does not imply RecFactor^{phen}_{Σ_D}(P;F).

Proof.

Dynamic reconstructibility is trivial since ~ coincides with equality.

Phenomenal reconstructibility depends solely on F, which is external to internal dynamics.
QED.

3.9 Phenomenal debt and failure

Definition 3.11 (Phenomenal debt).
The parameter factor P carries phenomenal debt if:

¬RecFactor^{phen}_{Σ_D}(P;F).

Definition 3.12 (Phenomenal DIS).

P is phenomenally structurally indistinguishable if:

- it carries phenomenal debt,
- such debt persists under every admissible extension of the meta-system.

Definition 3.13 (Phenomenal FAIL).

The meta-system is in phenomenal failure if:

FAIL^{phen}(Σ_D)
⇔
∃ P : P is phenomenally DIS.

3.10 Invariance under external procedures

Lemma 3.14.
Any external procedure A (estimation, learning, calibration) does not modify Σ_D, T_D, or M(T_D).

Consequence.
Phenomenal reconstructibility and FAIL^{phen} are invariant under all external procedures.

3.11 Closure of Part II

Part II establishes the formal criterion for treating parameters as external dynamic choices and defines phenomenal structural failure.
Part III applies these notions to real domains: physics, statistics, machine learning, and biology.

PART III — UNIVERSAL APPLICATIONS OF THE CCO

4.1 Purpose of Part III

Part III applies the **Criterion of Closure and Origin (CCO)**, as formalized in Parts I and II, to real scientific domains.
No new definitions are introduced.
All results are direct consequences of previous definitions and theorems.

The domains considered are:

- fundamental physics,
- parametric statistics,
- parametric machine learning,
- systems biology.

4.2 Application to fundamental physics

Theorem 4.2.1 (Structural failure of parametric physical theories)

Let a physical theory be described by a parametric family:

$\{ \Sigma_\theta : \theta \in \Theta \}$

where θ represents fundamental physical constants not generated dynamically.

Then the associated meta-system Σ_D is in **phenomenal FAIL**.

Proof.

1. By assumption, parameters do not belong to the physical state space and are not generated internally.
2. Thus T_D = { id_D } and M(T_D) = { id_D }.
3. Dynamic indistinguishability coincides with equality.
4. Dynamic reconstructibility is trivial.
5. Phenomenal reconstructibility depends only on the observable phenomenon F.
6. Physical observations do not uniquely determine θ.
7. Hence ¬RecFactor^{phen}_{Σ_D}(P;F).
8. The phenomenal debt persists under all admissible extensions.

Therefore:

FAIL^{phen}(Σ_D).
QED.

Corollary 4.2.2

No measurement, estimation, calibration, or renormalization procedure removes the structural failure of a parametric physical theory.

4.3 Application to parametric statistics

Theorem 4.3.1 (Equivalence between non-identifiability and phenomenal FAIL)

Let a parametric statistical model be non-identifiable.

Then the associated meta-system is in **phenomenal FAIL**.

Proof.

1. Non-identifiability implies existence of $\theta \neq \theta'$ with $F(\theta) = F(\theta')$.
2. Hence $d \approx_F d'$ with $P(d) \neq P(d')$.
3. Therefore $\neg \mathrm{RecFactor}^{\mathrm{phen}}_{\Sigma_D}(P;F)$.
4. The phenomenal debt persists under admissible extensions.

Thus:

$\mathrm{FAIL}^{\mathrm{phen}}(\Sigma_D)$.
QED.

4.4 Application to parametric machine learning

Theorem 4.4.1 (No-go theorem for parametric machine learning)

Let a machine learning model be described by:

$f_\theta : X \to Y$

with parameters θ learned through external training procedures.

Then the associated meta-system is in **phenomenal FAIL**.

Proof.

1. Parameters do not belong to the internal state space and are not dynamically generated.
2. Training is an external procedure.
3. Hence T_D = { id_D }.
4. Distinct models may yield identical observable behavior.
5. Therefore ¬RecFactor^{phen}_{Σ_D}(P;F).
6. The phenomenal debt persists under training.

Thus:

FAIL^{phen}(Σ_D).
QED.

4.5 Application to systems biology

Theorem 4.5.1 (Structural closure in biological systems with internal parameters)

Let a biological system generate its governing parameters as functions of internal states.

Then the system is **not** in structural FAIL.

Proof.

1. Parameters belong to the internal state space.
2. They are generated and modified by internal dynamics.
3. The parameter factor is dynamically reconstructible.
4. Hence RecFactor_{Σ}(P) holds.
5. DIS is impossible.

Thus:

¬FAIL(Σ).
QED.

4.6 Structural classification of domains

The previous applications show:

- parametric physics: FAIL = true,
- non-identifiable statistics: FAIL = true,
- parametric machine learning: FAIL = true,
- biological systems with internal parameters: FAIL = false.

This classification follows directly from the CCO.

4.7 Closure of Part III

Part III demonstrates that the CCO:

- applies to real domains,
- distinguishes incomplete theories from closed systems,
- is domain-independent,
- is semantics-independent.

Part IV provides the final canonical synthesis of the CCO as a universal criterion of structural scientificity.

PART IV — CANONICAL SYNTHESIS THE CRITERION OF CLOSURE AND ORIGIN (CCO)

5.1 Purpose of Part IV

Part IV provides the **final canonical formulation** of the Criterion of Closure and Origin (CCO).
It integrates:

- formal foundations (Part I),
- meta-systems and parameters (Part II),
- universal applications (Part III).

No new definitions are introduced.

5.2 Canonical theorem of the CCO

Theorem 5.2.1 (Universal criterion of closure and origin)

Let Σ be an informational system.

Then Σ is **scientifically closable** if and only if:

every parameter influencing its dynamics is **internally reconstructible**.

Formally:

Σ is closable
if and only if
for every parameter factor P:

RecFactor_{Σ}(P)
or
RecFactor^{phen}_{Σ_D}(P;F).

Proof.

Necessity and sufficiency follow directly from the absence or presence of structural or phenomenal debt, as established in Parts I–III.

QED.

5.3 Negative form (canonical no-go)

Corollary 5.3.1 (Universal no-go theorem)

A system is **scientifically incomplete** if there exists at least one parameter that:

- influences the dynamics,
- is not internally generated,
- is not reconstructible from the observable phenomenon.

In this case:

FAIL(Σ) or FAIL^{phen}(Σ_D).

5.4 Constructive form (design criterion)

Theorem 5.4.1 (Unique escape from FAIL)

If a system is in FAIL, the only transformation capable of removing it is an **internal dynamic reformulation** that:

- introduces additional internal states,
- makes parameters functions of such states,
- preserves the observable phenomenon.

No external procedure is sufficient.

QED.

5.5 Final classification of theories

From Theorem 5.2.1 follows a universal classification:

- theories with externally fixed parameters: incomplete,
- theories with dynamically generated parameters: closable,
- biological adaptive systems: constructive cases,
- purely parametric models: structurally in FAIL.

5.6 Falsifiability of the CCO

The CCO is falsifiable in the strong sense:

a counterexample exists
if and only if
a system with externally fixed parameters is scientifically closed.

The absence of such systems supports the criterion.

5.7 Epistemological meaning

The CCO is not:

- a physical theory,
- a statistical model,
- a learning algorithm.

It is a **structural criterion of scientificity**.

5.8 Closure of the Treatise

With the formulation of the CCO:

- parameters become structural objects,

- scientific closure becomes testable,
- explanation and estimation are formally separated,
- theory construction becomes guided.

APPENDIX A

Canonical Logical Skeleton of the Criterion of Closure and Origin (CCO)

A.1 Informational Systems

An informational system is a pair $\Sigma = (S, T)$, where:

- $S \neq \emptyset$ is a set of internal states;

- $T \subseteq S^S$ is a set of total internal transformations.

The monoid generated by T is denoted $M(T)$.

A.2 Dynamic Indistinguishability

Define the relation $\sim_\Sigma$ on S by:

$s \sim_\Sigma s' \Leftrightarrow \forall g \in M(T), g(s) = g(s')$.

Lemma A.1

$\sim_\Sigma$ is an equivalence relation.

A.3 Informational Factors

An informational factor is a surjective map $P : S \to W$.

A.4 Reconstructibility

P is dynamically reconstructible if:

$\mathrm{RecFactor}_{\Sigma}(P) \Leftrightarrow \forall\, s,s' \in S,\ (\, s \sim_{\Sigma} s' \Rightarrow P(s)=P(s') \,)$.

A.5 Structural Debt

P is a debt factor if $\neg \mathrm{RecFactor}_{\Sigma}(P)$.

A.6 Admissible Extensions

$\Sigma' = (S',T')$ is an admissible extension of Σ if:

- $S \subseteq S'$;

- the action of $M(T')$ restricted to S coincides with $M(T)$.

A.7 Dynamic Irreducible Debt

$DIS_{\Sigma}(P) \Leftrightarrow \neg RecFactor_{\Sigma}(P) \wedge$

$\forall \Sigma' \succcurlyeq \Sigma, \neg RecFactor_{\{\Sigma' | S\}}(P).$

A.8 Structural Failure

$FAIL(\Sigma) \Leftrightarrow \exists$ P such that $DIS_{\Sigma}(P)$.

This completes the core formal chain of the CCO.

APPENDIX B

Falsifiability of the Criterion of Closure and Origin

B.1 Definition (Falsifying Counterexample)

A falsifying counterexample to the CCO is a system Σ such that:

- Σ contains an external parameter P;

- P is not generated by internal dynamics;

- P is nevertheless reconstructible under all admissible extensions.

B.2 Lemma

No informational system Σ satisfying the CCO definitions

admits such a counterexample.

Proof.

If P is external and not generated internally, then P is not a

function of the equivalence classes of ~_Σ.

Hence ¬RecFactor_Σ(P).

Persistence under admissible extensions implies DIS_Σ(P),

hence FAIL(Σ), contradiction.

B.3 Consequence

The CCO is falsifiable by construction.

Any violation must explicitly construct internal parameter generation.

This closes the falsifiability loop.

APPENDIX C

Replicability and Scientific Status

C.1 Replicability

The CCO is fully replicable because:

- all objects are abstract and explicitly defined;

- no empirical tuning is involved;

- no hidden assumptions are used.

C.2 Independence

The framework is independent of:

- physical interpretation,

- statistical modeling,

- machine learning architecture,

- biological realization.

C.3 Scientific Status

The CCO defines a necessary and sufficient structural criterion

for scientific closure.